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ABSTRACT

This unit of instruction on energy conservation in field crop production was designed for use by agribusiness and natural resources teachers in Florida high schools and by agricultural extension agents as they work with adults and students. It is one of a series of 11 instructional units (see note) written to help teachers and agents to educate their students and clients about the problems of energy shortages and strategies for energy conservation and management. This unit is organized into five modules. Topics covered in the unit include management practices that will reduce the energy required for crop production; tillage and no-tillage methods of crop production; irrigation; and pest control. The unit contains student performance objectives, content information, teaching-learning activities, student handouts, transparency masters, and evaluation instruments. (KC)

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ED2105536

LOW ENERGY TECHNOLOGY

A UNIT OF INSTRUCTION ON

ENERGY CONSERVATION IN FIELD CROP PRODUCTION

Developed by

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Institute of Food and Agricultural Sciences
University of Florida
Gainesville
1981

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This unit of instruction was developed as part of the Low Energy Technology Program of the Institute of Food and Agricultural Sciences, University of Florida. Additional copies of this and other units of instruction in Low Energy Technology can be obtained by contacting the Instructional Materials Service, 101 Rolfs Hall, University of Florida, Gainesville, Florida 32611

CE 030 828

Introduction

Faced with constantly increasing prices of fuel and other forms of energy, farmers are concerned about finding ways to cut energy consumption in crop production.

Good management practices can reduce energy requirements for field crops. Particular attention should be paid to yield increases when evaluating energy costs per acre. Higher yields by more intensive management can result in less energy input per unit of crop produced. This is an important factor to consider when determining energy cost per acre.

This unit of instruction on Energy Conservation in Field Crop Production includes five modules, with student performance objectives. Upon completion of each module, the student will be able to:

Introduction to Field Crops

Module: Field Crops

1. List and explain five management practices that will reduce the energy required for crop production.

Module: Tillage

1. Explain five factors that affect fuel consumption in tillage operations.
2. Define the terms minimum tillage and no-tillage.
3. List five advantage of no-tillage crop production.
4. List two major disadvantages of no-tillage crop production.
5. Compare fuel consumption in conventional and no-tillage methods of crop production.

Module: Irrigation

1. List three methods of reducing energy when irrigating field crops.
2. Identify the major differences between two water systems with regard to energy savings.

3. Define irrigation scheduling and give one example.

4. List one advantage and one disadvantage of irrigating at night.

5. Identify two benefits from using irrigation practices.

Module: Fertilization

1. Collect soil samples for soil testing.

2. Determine the correct fertilizer analysis for optimum crop growth after a soil test has been made.

3. Explain two ways of saving energy when applying fertilizer.

Module: Pest Control

1. Name five kinds of pest and give an example of each.

2. Write in 50 words or less, a definition of Integrated Pest Management.

3. List the six steps involved in a successful, low energy IPM program.

4. List three cultural practices that reduce energy in controlling weeds.

This unit contains student performance objectives, content information, teaching activities and student handouts.

This unit of instruction was designed for use by agribusiness and natural resources education teachers in Florida high schools and by extension agricultural agents as they work with their clients. This unit was developed by the Department of Agricultural and Extension Education, Institute of Food and Agricultural Sciences as part of the Low Energy Technology Program.

UNIT: FIELD CROPS

STUDENT PERFORMANCE OBJECTIVES	CONTENT
The student will be able to:	
1. List and explain five management practices that will reduce the energy required for crop production.	Management Practices: Crop Rotations Variety Selection Soil Testing Utilizing Legumes Minimum Tillage Multiple Cropping Pest Management Combining Operations

MODULE: INTRODUCTION TO FIELD CROPS

T	TEACHING-LEARNING ACTIVITIES
	Read handout: Conserving Energy in Field Crop Management. After reading the handout Conserving Energy in Field Crop Management, the student shall list and define five management practices that reduce the amount of energy required to produce a crop. All units and written work should be placed in the student notebook under the unit Field Crop Production. Have students complete Evaluation.

MULTICROPPING
MINIMUM
TILLAGE

MMT-2
April 1980

Conserving Energy in Field Crop Management

E. B. Whitty*

Florida Cooperative Extension Service / Institute of Food and Agricultural Sciences / University of Florida / J. T. Woeste, Dean

Faced with constantly increasing prices of fuel and other forms of energy, those engaged in crop production are becoming more and more concerned about finding ways of cutting energy consumption.

Good management practices can help reduce the energy requirements for field crops. Although, generally, the energy costs per acre will be reduced, in some situations it may be increased. But, because of yield increases, the energy costs per bushel or pound of crop produced will be reduced.

The concept of higher yields by more intensive management, but with less energy input per unit of crop produced, is very important in understanding agriculture's need for energy.

The total acreage under cultivation for all field crops in many states has not increased since the early part of this century. There have been decreased acreages for most crops, but yields have greatly increased. In Florida, for example, in 1935 there were 7,560,000 bushels of corn harvested from 756,000 acres In 1978, however, 19,240,000 bushels were produced on only 370,000 acres.

Peanuts are another example of higher yields on fewer acres. In 1942, about 115,000 acres were harvested and 65,550,000 pounds produced, while in 1978 only 54,000 acres produced 182,520,000 pounds. Increasing the yield per acre reduces energy costs of clearing new land or of farming extensive acreages.

Farmers can use management practices that will result in less energy needed to produce each pound of harvested crop. Included in these practices are crop rotation, variety selection, soil testing, growing legumes, minimum tillage, multiple cropping, pest management and combining cultural operations.

Crop Rotation

Crop rotation primarily reduces pest problems, which leads to higher yields and less dependence on pesticides. Many diseases, nematodes or insects are fairly specific as to the plants they will attack. Planned rotations, involving crops that are not hosts for the same pests, will lead to fewer losses in all crops.

Crop rotations can be used advantageously to control certain weeds in crops where effective herbicides are not available. For example, it is difficult to control Florida beggarweeds with herbicides that do not damage peanuts. But if corn is grown preceeding the peanuts, hebicides can be used that will control beggarweeds, thus reducing the beggarweed population even during the peanut crop.

Variety Selection

Selecting the better varieties of a crop species can increase yields without increasing energy requirements for production. New varieties that are better adapted to certain environmental conditions or changing market situations are constantly being released.

Selecting appropriate pest-resistant varieties can reduce losses to diseases, nematodes or insects. Selecting an appropriately resistant variety can also reduce the dependance on pesticides and, consequently, energy requirements for crop production. In many cases, varietal resistance is the most effective method to combat certain pests.

Soil Testing

Soil testing provides useful information for developing liming and fertilization programs. The need for lime, and the type of lime needed, can be determined by a soil test. Lime can increase crop yields, improve nodulation of legumes, and improve the utilization of plant nutrients. Efficient fertilization programs depend on soil tests to determine soil nutrient levels. A knowledge of soil nutrient levels allows a farmer to select the type and amount of fertilizers most suitable for his crops. Thus, needed fertilizers can be applied for efficient production, and application of unneeded fertilizer is avoided.

* E. B. Whitty is professor and Extension agronomist, Agronomy Department, Gainesville.

Utilizing Legumes

Legume cover crops were once grown extensively because of the nitrogen they remove from the air and add to the soil. This nitrogen was then used as a nutrient by subsequent crops grown on the land. As nitrogen fertilizers became less expensive, they substituted for the legume cover crops. However, recent increases in the price of nitrogen fertilizers, much of which is due to the higher cost of petroleum products, have caused many farmers to reconsider the use of legume cover crops.

The amount of nitrogen added by a legume varies, but commercial nitrogen fertilizer needs can be reduced by use of legumes. Legumes are also important in forage production because they provide protein to grazing animals without requiring nitrogen fertilizers and also provide nitrogen to the grass sod, all at a reduced cost for nitrogen fertilizer.

Minimum Tillage

The "no-till" method has become common in production of corn and soybeans in some areas of the United States. "No-till" means no tillage is practiced except that needed to place the seed in the soil. Herbicides are used to kill vegetation normally controlled by tillage practices. Although no-till has not been used extensively in some states, a number of farmers have successfully used the practice.

The potential energy savings, in addition to water and soil conservation, are substantial. The U.S. Department of Agriculture estimates that 5.32 gallons of diesel fuel are needed for each acre under conventional tillage compared to only 0.88 gallon needed for each acre under no-till. Labor costs are reduced from 1.98 hours per acre for conventional tillage to 0.78 hours for no-till. Naturally, herbicide and perhaps other pesticide costs are increased, but energy requirements in terms of fuel are substantially reduced.

Multiple Cropping

Multiple cropping offers a means of increasing crop production without the cost of clearing new land. With this technique, two crops can be grown on the same land within one year. Triple cropping is possible in some instances.

Total costs can normally be decreased by multiple cropping rather than growing a single crop a year on the same land. In most cases there will be greater utilization of fertilizers, equipment, building and labor on a year-round basis with multiple cropping rather than single cropping.

Multiple cropping will generally reduce the energy requirements when compared to growing the same amount of product in a single cropping system. Effective use of multiple cropping will require closer management and tighter schedules than single cropping.

Pest Management

Pest management can reduce the amount of pesticides applied to a crop. Allowing predators and parasites to aid in the control of pests rather than totally depending upon pesticides can result in substantial savings of energy resources. Some physical, but not economic, losses may be necessary for the pest population to become adequate for predator and parasite increase. Insect management programs are available for many crops. County Extension offices can assist farmers in developing pest management programs.

Combining Operations

Combining cultural operations can reduce the number of times that a tractor and other equipment must be driven over each acre of land. A tractor can pull more than one implement at a time--for example, a herbicide sprayer can be combined with a harrow. Tank mixing compatible pesticides and fertilizer is another. Not only does the combining of cultural operations reduce energy and labor requirements, it also reduces soil compaction that results from excessive traffic.

Conclusion

Management practices that result in energy conservation are numerous. By careful examination of farming programs, producers can select those practices that can help them reduce their energy requirements. Extension specialists can offer information and assistance as needed.

This publication was promulgated at a cost of $98.30, or 3.9 cents per copy, to provide producers with information on multicropping/minimum tillage and implications for their operations. 4 - 2.5M - 80

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EVALUATION

1. List and explain five management practices that will reduce the energy required for crop production.

LOW ENERGY TECHNOLOGY
ENERGY CONSERVATION IN FIELD CROP PRODUCTION

UNIT: FIELD CROPS — MODULE: TILLAGE

STUDENT PERFORMANCE OBJECTIVES	CONTENT	TEACHING-LEARNING ACTIVITIES
The student will be able to:		
1. List five factors that affect fuel consumption in tillage operations.	Major factors in fuel consumption: Plow Depth Implement Adjustment Plowing Speed Tractor Maintenance Tractor Overload	Read handout, Field Crop Production-Tillage; Have students complete handout, Factors Affecting Fuel Consumption.
2. Define the terms, minimum tillage and no-tillage.	Minimum tillage is the disturbance of the soil as little as possible to produce a crop. No-tillage is a form of minimum tillage that is described as "The opening of a slot in the soil, only deep and wide enough to properly plant the seed."	The student shall write the definitions of these terms and enter them into their notebook under Field Crops.
3. List five advantages of no-tillage crop production.	Advantages of no-tillage crop production: Less labor Lower production costs Conserves moisture Imporved yields Double cropping Reduces erosion Food and cover for wildlife	Read handout, Conserving Energy with No Tillage

LOW ENERGY TECHNOLOGY
ENERGY CONSERVATION IN FIELD CROP PRODUCTION

UNIT: FIELD CROPS — MODULE: TILLAGE

STUDENT PERFORMANCE OBJECTIVES	CONTENT	TEACHING-LEARNING ACTIVITIES
The student will be able to:		
4. List two major disadvantages of no-tillage crop production.	Disadvantages of no-tillage production: Lower soil temperature Increased pest problems Requires 10% more seed	Discuss in class, the advantages and disadvantages of the actual no-tillage methods and equipment that were observed during the field trip. Have students write a short paragraph either for or against no-tillage explaining their reason.
5. Compare fuel consumption in conventional and no-tillage methods of crop production.	No-tillage methods use one seventh the amount of diesel fuel as conventional tillage methods.	Read handout, Conserving Energy with No-Tillage Have students compare the cost of diesel fuel used in conventional tillage vs no-tillage. List costs by each operation such as plowing, discing, planting, cultivation, and spraying. Make up a chart to compare the differences using current prices of diesel fuel. Have students complete Evaluation.

HANDOUT

FIELD CROP PRODUCTION - TILLAGE

Uncertainties in fuel supplies along with increasing fuel costs are forcing farmers and agricultural researchers to examine methods of energy conservation in agricultural production. Energy consumed in tillage operations is one area where several methods are available to growers to conserve fuel.

Common reasons for tillage include: loosening a compacted soil; controlling weeds, insects and diseases; and incorporating fertilizer, lime pesticides or crop residues. In the absence of these or other reasons, it may be desirable to eliminate tillage operations. If tillage is necessary, consideration of the following factors can improve fuel efficiency.

(1) plowing deeper than necessary increases fuel consumption. If the purpose of plowing is to destroy weeds, insects or prevent diseases; don't plow any deeper than required to cover crop residues and weeds completely.

(2) Keeping tractor engines and implements properly adjusted and in good condition to improve fuel efficiency. Improper adjustment of moldboard plows increases the draft and fuel consumption. Even minor maladjustments which may not adversely affect the quality of plowing may cause as much as 15 percent increased fuel consumption.

(3) Plowing speed directly affects fuel consumption. Recent models of moldboard plows are designed to be used at speeds of 4.0 to 4.5 mph. Exceeding designed speed moves soil sideways a greater distance than necessary, resulting in increased draft and fuel use.

(4) Proper maintenance of power units reduce fuel consumption. Dirty or faulty spark plugs can increase fuel consumption up to 15 percent. An improperly tuned engine wastes fuel.

(5) Avoid overloading tractors since this results in excessive fuel use. When using a large tractor for light work, shift up to a higher gear and throttle back to a lower rpm. Never throttle back to less than 50 percent of rated, or to the point where the engine appears to be "laboring" or "lugging" to handle the load.

Use of minimum tillage or no-tillage production methods can significantly reduce energy consumed in tillage operations. Studies in Delaware demonstrated that no-tillage consumed between 1/7 and 1/5 as many horsepower hours, 1/6 to 1/4 as much fuel, and 1/3 as much labor as conventional tillage methods.

HANDOUT

FACTORS AFFECTING FUEL CONSUMPTION

Purpose: The major intent of this demonstration is to acquaint students with various factors which increase or decrease the amount of fuel consumed in the tillage operation.

Materials:

- Gasoline powered tractor and appropriate tillage equipment.
- One 3/8" copper "T" valve
- 12" rubber gas line hose
- Graduated cylinder capable of holding one to two gallons of fuel.
  * note, cylinder must be vented at top.
- Assortment of mechanics hand tools.

Procedure:

1. Attach the graduated cylinder securely to the tractor to be used for the demonstration.
2. At some point between the fuel tank and fuel pump, "break" the gas line and insert the 3/8" copper tee valve, using short pieces of the rubber gas hose (see figure #1)
3. Using the remaining rubber gas hose, attach one end to the tee valve and the other to the graduated cylinder.
4. Add a premeasured amount of fuel to the graduated cylinder.
5. Move entire demonstration to a field ready to be plowed.
6. Plow several furrows at:
   1. Different depths
   2. Different ground speeds
   3. Different engine rpms.

Record the amount of fuel consumed after each furrow has been plowed. Plow several furrows with one spark plug removed - record fuel consumption - replace spark plug.

* Caution: Do not remove or replace spark plug ever with engine running!

7. Record all data in student notebooks:

Follow up:

1. Return to classroom and determine optimum plow depth, ground speed and engine RPM for maximum fuel economy.

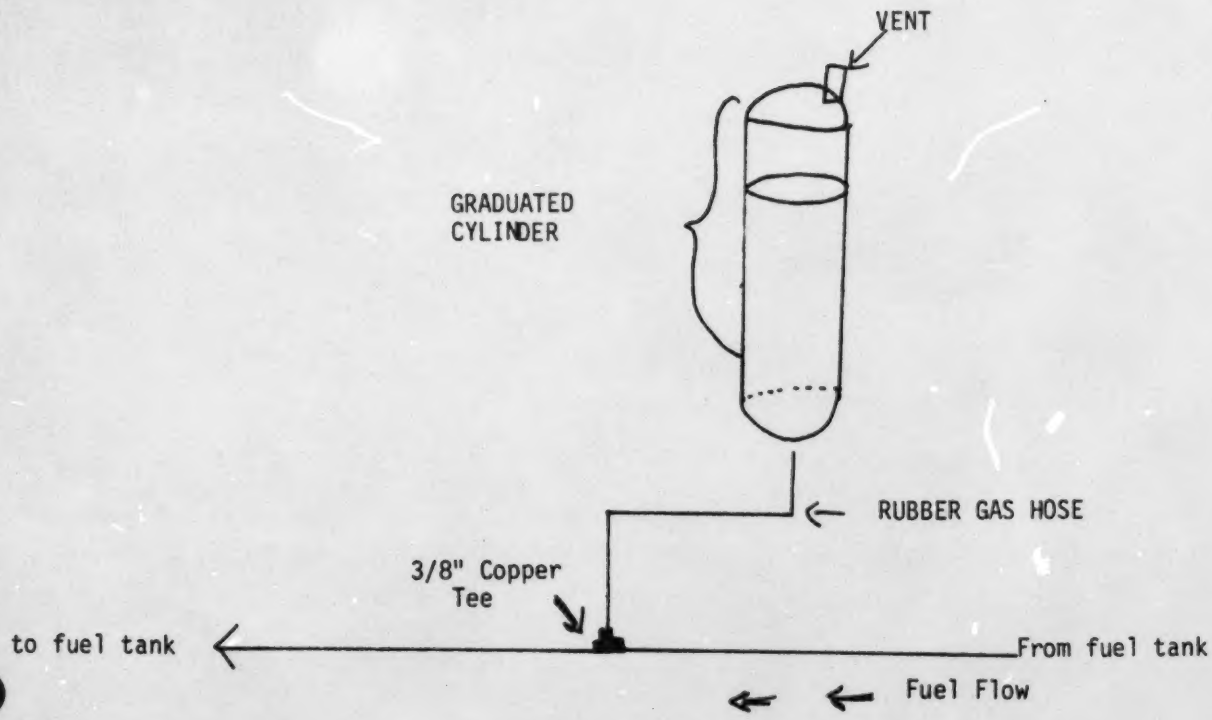

VENT
GRADUATED
CYLINDER
RUBBER GAS HOSE
3/8" Copper
Tee
to fuel tank
From fuel tank
Fuel Flow

Figure 1

Conserving Energy with No-Tillage EC-37

Stretch America's Vanishing Energy

FLORIDA COOPERATIVE EXTENSION SERVICE

Conserving Energy with No-Tillage

W. K. Robertson, Soil Chemist G. M. Prine, Associate Agronomist

ENERGY CONSERVATION FACT SHEET

University of Florida • Institute of Food and Agricultural Sciences

Two hundred years ago, very little energy other than human went into crop production. At that time, a farmer in the United States produced little more than enough food for himself. Today, one of our nation's farmers produces enough for himself and fifty others. The reason for this advancement is technology with its many contributing factors, such as: machinery, fertilizer, crop varieties, pesticides, and irrigation, to name a few. Most of these factors require an input of fossil fuel, either directly or indirectly.

Agriculture uses three percent of the energy in the United States.[2] This may not seem to be much considering the task performed—feeding over 200 million people at home and exporting much more to hungry nations. However, each year agriculture consumes about eight billion gallons of petroleum and petroleum products, our scarcest energy resource. This is about ten percent of the total petroleum marketed in the United States.[3]

The cost and availability of fuel is of growing concern. Efforts should be made to conserve petroleum, particularly if it can be done without sacrificing production. This fact sheet evaluates no-tillage, which is one method of conserving energy in crop production.

NO-TILLAGE

By definition, "no-tillage" means that no tillage is done except that needed to place the seed in the soil —a one time operation. Herbicides are used to kill vegetation normally controlled by tillage practices. For this reason, no-tillage success depends to a large extent on the effectiveness of the herbicides in controlling weeds.

Research with no-tillage crop production, which has been done for years, shows that the potential energy savings are substantial. No-tillage has also proved to be a means of water and soil conservation.

How It Is Done

A no-tillage planter tills a narrow strip of soil and plants the crop in it. At the same time, fertilizer is placed beside the row and below the seed. Herbicides are also broadcast, and insecticides and/or nematicides may be applied.

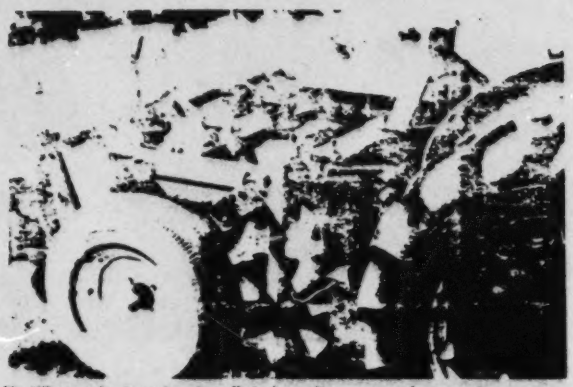
The no-tillage method has been used successfully for planting corn, soybeans, sorghum, peanuts, and other crops in some states. The ground cover at the time of planting the above mentioned crops has been crop residues, grass sod, or small grains.[4, 5]

In general, the best management practices known for each crop must be used. For instance, narrow rows are needed when planting sorghum in sod and higher nitrogen rates are required for growing corn in sod. Two cash crops a year are possible when soybeans are planted by no-tillage following wheat harvested for grain.

Fuel Consumption

When using the no-tillage method, herbicide and perhaps pesticide costs are increased, but energy requirements in terms of fuel consumption are substantially reduced. Table 1 gives a comparison of the diesel fuel consumption in gallons per acre for conventional tillage and no-tillage. Notice that the no-tillage method uses less than one-seventh the amount of diesel fuel as does conventional tillage with four cultivation trips through the field.

COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS, STATE OF FLORIDA, IFAS, UNIVERSITY OF FLORIDA, U. S. DEPARTMENT OF AGRICULTURE, AND BOARDS OF COUNTY COMMISSIONERS, COOPERATING



No-tillage planter showing fluted coulter—one of many types commercially available.

Table 1. Diesel Fuel Consumption (Gal/Acre) with Conventional and No-Tillage Methods.[1]

Operation	Conventional: Cultivation & Herbicide	Conventional: Cultivation & Herbicides	No-Tillage
Plow 8" deep	1.68	1.68	0
Heavy offset disc	0.95	0.95	0
Planting	0.50	0.50	0.35
Cultivation	1.80 (4 times)	0.45 (1 time)	0
Spray	0	0.10 (1 time)	0.29 (3 times)*
Total	4.93	3.68	0.64

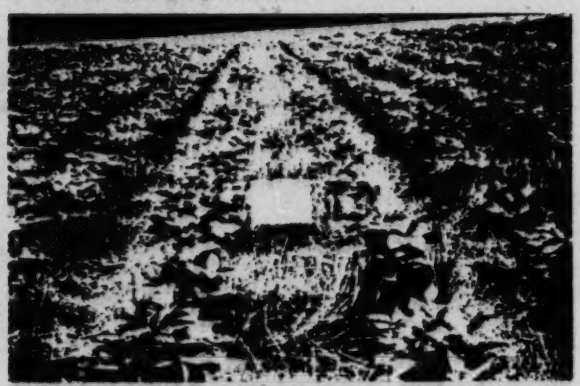
*Includes pre-plant application and two post-directed sprays.

Advantages

Planting by the no-tillage method conserves fuel and has other benefits with energy saving connotations as well.

No-tillage has these benefits:

- Less fuel is used because of fewer trips across the field.
- Higher yields often result.
- There is greater management flexibility. No time is lost for land preparation.



Soybeans planted with no-tillage planter in rye treated at planting time with paraquat and [illegible] herbicides.

- Land use may be intensified. It is possible to plant a second crop without a delay that can reduce yield.
- It is possible to farm lower cost land. No-tillage works particularly well on sloping land.
- There is less erosion since residues remain on the surface to reduce water runoff.
- Soil structure improvement is possible because of the saving of organic matter. This is particularly true since the conventional methods may require burning of crop residue.
- There is greater water penetration and consequently less loss from evaporation.
- There is less chance of a tillage pan since no-tillage is a once over operation.
- It saves time throughout the season because of fewer field operations.
- There is a lower investment for machinery.
- Less labor is necessary.
- Since only one machine is required, the maintenance cost of machinery is lower.

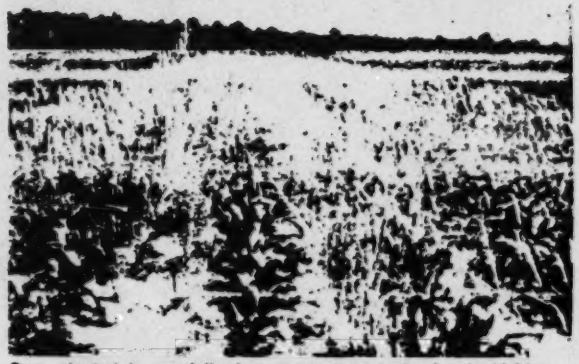
Disadvantages

Farmers have been reluctant to adopt reduced tillage practices for a number of reasons.[2] All these factors must be taken into consideration when adopting the no-tillage practice:

- At present, the cost of fuel and labor for most crops represents a relatively small portion of the total cost. However, with imminent price increases for petroleum and possible limited supplies, no-tillage may become more economically feasible.
- There is risk that weed control will not be effective. This is being reduced as more specific herbicides are developed.
- The no-tillage system is limited to sandy and medium-textured soils since it doesn't work well on fine-textured soils.
- Pests are more troublesome because the residues are a haven for insect breeding. An insect spraying program may have to accompany the no-tillage practice.
- Farmers must plant 10 percent more seed since seeds often are not uniformly buried in the rough seed beds.
- The herbicides necessary to make no-tillage a success are costly. But as no-tillage planting increases, manufacturers will sell more herbicides and, therefore, the cost per unit should decrease.

Although no-tillage has received slow acceptance in some states, it has become very popular in others. In some areas of the United States, it is common in corn and soybean production. In fact, some states

Foreground corn planted in sod by no-tillage method following treatment with glyphosate herbicide.



Corn planted in rye following paraquat and atrazine herbicides.

plant up to 50 percent of their crop acreage by the no-tillage method.

Many farmers have successfully used no-tillage. If and when fuel costs increase and supply becomes limited, the practice may become economically attractive to more farmers. The increased use of no-tillage means less petroleum consumption.

For more information, contact your county Extension office.

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EVALUATION

1. List five factors that affect fuel consumption in tillage operations.

2. Define the terms, minimum tillage and no-tillage.

3. List five advantages of no-tillage crop production.

4. List two major disadvantages of no-tillage crop production.

5. Compare fuel consumption in conventional and no-tillage methods of crop production.

LOW ENERGY TECHNOLOGY
ENERGY CONSERVATION IN FIELD CROP PRODUCTION

UNIT: FIELD CROPS — MODULE: IRRIGATION

STUDENT PERFORMANCE OBJECTIVES	CONTENT	TEACHING-LEARNING ACTIVITIES
The student will be able to:		
1. List three methods of reducing energy when irrigating field crops.	Methods of reducing energy when Reduce amount of water applied Improve irrigation efficiency Improve pumping performance Reduce pressure	Read handout, Irrigation Using the land laboratory, compare distribution (area) and application (volumn) rates of various types of sprinklers at various pressures. Construct a chart showing the results of field trial Students should place charts in student notebook, under unit titled. Field Crops.
2. Identify the major differences between two water systems with regard to energy savings.	Types of Irrigation Systems used in Florida: Permanent Solid-set Mechanical-move Sub-surface Drip or trickle	Read handout, Irrigation Systems for Crop Production in Florida. Assign the students two different field crops with a specific amount of acreage and shape of field. Have students select the most appropriate water system with regard to energy savings.

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LOW ENERGY TECHNOLOGY
ENERGY CONSERVATION IN FIELD CROP PRODUCTION

UNIT: FIELD CROPS — MODULE: IRRIGATION

STUDENT PERFORMANCE OBJECTIVES	CONTENT	TEACHING-LEARNING ACTIVITIES
The student will be able to:		
3. Define irrigation scheduling and give one example.	Irrigation scheduling is the frequency of water Examples water account system tensiometer	Read handouts, Irrigation Scheduling Fringe Benefits From Irrigation, Energy Management in Irrigation. Invite an irrigation specialist from the county Extension office to speak to class about irrigation schedule and possibly show an actual tensiometer or other methods being used today.
4. List one advantage and one disadvantage of irrigating at night.	Night time irrigation advantages reduces evaporative losses weather conditions are more favorable for less water application wind vilocity application lower temperature more humidity disadvantages plants more prone to foliar diseases	Review handout, Irrigation Have students set up 2 identical plots of tomatoes Irrigate one plot at night and the other during the day. After two weeks growth discontinue irrigation and observe the time required for each plant to wilt. Discuss in class.

HANDOUT

IRRIGATION

Because of the rising energy costs, farmers must look at every aspect of their production system and find ways to reduce costs and their energy use. A growing concern about water shortages also exists. It is possible for a grower who combines energy conservation techniques and good irrigation management practices to conserve both water and energy, as well as reducing production costs.

Four primary means of reducing energy consumed for irrigation are: reducing the amount of water applied, improving irrigation efficiency, improved pumping plant performance, and reducing pressure.

Methods to reduce the amount of water applied include scheduling irrigation and conserving soil moisture. Moisture meters, evaporation pans, and soil augers are instruments that can be used in determining when and how much to irrigate. Another method of scheduling irrigation called the "Bookeeping" method or "Accounting Method" involves recording rainfall and irrigation data and subtracting daily evapotranspiration losses.

Utilization of mulches or no-tillage production methods conserves soil moisture and may be useful in reducing amounts and frequency of irrigation.

Much of the energy requirement for irrigation is determined by the type of irrigation system used. Water-use efficiency also varies among different systems with drip or trickle, generally being the most efficient. The major drawback of trickle irrigation in field crop production is the high initial cost.

Factors affecting the efficient application of water are wind vilocity, temperature, and humidity. When there is little or no wind, when the temperature is low and the humidity is high are good conditions for water application. These conditions occur more often at night. By irrigating at night, the grower can take advantage of optimum conditions and save energy and water. However, one disadvantage may be an increase in foliar disease fo the crop sprayed.

Pumping plant efficiency greatly effects fuel consumption. A Nebraska study showed that less than 2 percent of the pumps examined met standard pumping performance levels. The primary causes of reduced performance were neglect, maladjustment, few checkups, and minimal maintenance. Most problems were easily correctable and could significantly reduce energy consumption.

Keeping pressures on sprinkler irrigation systems at the lowest pressure that still provides adequate distribution of irrigation water will save energy. Additional energy savings may be realized by using more sprindlers designed to operate at lower pressure, or the use of low pressure nozzles on continuously moving systems.

Users of electrically powered irrigation systems may be able to reduce the cost of power by scheduling irrigation during off-peak demand periods. Many electric utilities will supply power at reduced rates during off-peak demand periods. Increased consumption during off-peak demand periods allows utilities to distribute their load more evenly and operate generators at higher efficiencies.

The use of irrigation equipment to apply fluid fertilizers or herbicides can save energy by combining two operations. Provided that both irrigation and fertilizer or herbicides application are required, both can be put out for essentially the same energy cost as irrigation alone, saving the energy that would be used in conventional applications of these materials. Eliminating another trip across the field with the tractor will also help prevent soil compaction and save diesel fuel.

HANDOUT

Fringe Benefits From Irrigation

The use of irrigating systems have the potential to save energy by combining one or more operations with the existing irrigation system. Some of these operations that have been used successfully are freeze protection and application of fertilizer, herbicides or pesticides.

Research and field experience has shown that sprinkler irrigation can be used to provide cold protection for certain fruits, ornamentals, vegetables and citrus nurseries. The application rates for irrigation are determined not only by the temperature, but the presence of high winds and low dew point temperatures. If these weather conditions are in effect, the application rate will be higher.

Frost damage affects plants with temperatures beginning at about 28°F. Well planned irrigation can prevent this damage by maintaining a leaf temperature between 31° and 32° F.

Sprinkling provides cold protection because of the heat energy that is released as the water goes through a chemical change and changes from liquid to ice. When water is freezing, its temperature will be near 32° F.

Effective cold protection will be obtained when clear ice and icicles form on the plant during the entire cold protection operation. It is extremely important that proper irrigation system design and adequate sprinkling rates are used. Damage from water applied at too low a rate can cause more damage than if no protection was used.

Citrus farmers are now waiting to use their sprinklers till temperatures drop lower in order to save energy. By doing so, they will save the tree but not the fruit.

Irrigation can be used to improve both yields and quality of some crops by reducing the temperature on hot days. High temperatures can be lowered by the evaporation of the water as it is sprinkled onto the field. Evaporation requires heat which is taken from the surrounding air and plants, thus reducing the temperature by as much as 15° F to 20° F. The greatest evaporation takes place in hot, dry air.

Liquid fertilizers can be distributed through irrigation systems. There are at least three major advantages to this system. They are 1). it saves labor 2). fertilizer can be applied more accurately and evenly and 3). fertilizer is applied in a form which is readily available to the plants. Some of the disadvantages are 1). materials containing phosphoric acid concentrate near the surface of the soil and anhydrous and free ammonia in other nitrogen solutions may be lost in the air when applied through irrigation

water. 2). free ammonia may damage green foliage as well as some other problems.

Persons trained in soils and use of fertilizers should be consulted before injecting any material in an irrigated system.

Crops may be protected from weeds, insects and fungi by the application of pesticides and herbicides through irrigation systems. Special metering equipment should be used.

EVALUATION

1. List three methods of reducing energy when irrigating field crops.

2. Identify the major differences between two water systems with regard to energy savings.

3. Define irrigation scheduling and give one example.

4. List one advantage and one disadvantage of irrigating at night.

5. Identify two benefits from using irrigation practices.

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Energy Management in Irrigation

Energy Management in Irrigation

Dalton S. Harrison and Allen G. Smajstrla*

Florida Cooperative Extension Service / Institute of Food and Agricultural Sciences / University of Florida / J. T. Woeste, Dean

Because of the rising costs of energy, it is important that the agricultural producer examine every aspect of his production system and seek ways to optimize energy use. A growing concern about water shortages also exists. It is possible for a producer who combines energy conservation techniques and good irrigation management practices to conserve both water and energy, as well as reduce his production costs.

Although 60 million acres of croplands in the United States are irrigated, this comprises only 13 percent of the total 458 million acres currently under cultivation. In Florida, despite an annual rainfall of 50 to 60 inches, 2.1 million acres or 26 percent of the croplands are irrigated. The annual value of production from these irrigated croplands is approximately $3 billion.

Irrigation is practiced in Florida on a greater percentage of cropland than the national average for the following reasons:

(1) Rainfall distribution is not uniform and many crops are grown during low rainfall months because of other desirable climatic conditions.
(2) The majority of Florida soils are sandy, with very low water-holding capacities. Unirrigated crops, therefore, suffer from frequent short-term droughts because of the low soil water storage.
(3) Many speciality crops for fresh fruit and vegetable markets are grown. Produce quality is very important in determining market value. Without irrigation, these crops could not be grown successfully. Irrigation makes possible year-round availability of most fresh fruits and vegetable crops.

IRRIGATION SYSTEM USES

Irrigation systems are primarily designed to efficiently convey water to satisfy a crop's requirements. However, other potential uses exist. In many types of systems, it is possible to distribute fertilizers, pesticides and herbicides.

Sprinkler irrigation systems can also be used for environmental control. Within limits, the system can be operated to prevent a crop from freezing in cold weather. The freezing irrigation water releases energy, keeping the temperature high enough to avoid damage to the crop.

In climates in which temperatures fluctuate widely, irrigation can be used to cool a crop to prevent it from budding until desired. An early budding crop can be killed by a late frost.

Finally, sprinkler irrigation systems can be used to cool sensitive crops on extremely hot days. Evaporative cooling from the crop leaves will lower the leaf temperature and prevent damage and growth reduction due to high temperatures.

IRRIGATION PUMPING COST CONSIDERATIONS

Irrigation pumping systems require large energy inputs. In most cases water must be lifted to field elevations from wells or surface water sources. Energy is also needed to distribute the water through a network of pipes and applicators such as impulse sprinklers and/or nozzles.

Fuels commonly used to power irrigation systems in Florida are diesel (55 percent), electricity (20 percent), L.P. gas (15 percent) and gasoline (10 percent). Diesel is a very popular fuel because of its performance efficiency, portability and availability, as compared to the other fuels listed. Performance efficiency is expressed in gallons of fuel used (or kilowatt-hours [KWH] for electrical units) per brake horsepower-hour produced by the power unit. Comparative values of performance efficiencies of the various fuels are listed in Table 1.

Table 1. Performance Efficiency of Irrigation Power Unit Fuels Used in Florida

Fuel	Performance Efficiency
Diesel	0.078[1]
Gasoline	0.112[1]
LP-Gas	0.138[1]
Electric	0.866[2]

[1] gallons per horsepower-hour.
[2] kilowatt-hours (KWH) per horsepower-hour.

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When purchasing an irrigation system, the producer should consider the most feasible type of fuel for its operation. Cost, efficiency and availability should all be considered before selecting a fuel. Other considerations should include cost and maintenance requirements of the power unit and fixed costs such as electrical service standby charges.

From Table 1, it is readily seen that diesel fuel is the most efficient of the liquid fuels used in Florida. However, the initial cost of a diesel power unit is usually considerably greater than that of other internal combustion engines.

To compare fuel consumption, calculate the daily fuel use and cost as follows:

(1) Multiply the continuous-load brake horsepower of the power unit (your dealer should provide this information) by the performance efficiency. This produces the gallons (or KWH) of fuel consumed per hour.

(2) Multiply the fuel consumption rate by the fuel cost in dollars per gallon (or KWH) to obtain fuel cost in dollars per hour.

IRRIGATION SYSTEM COST CONSIDERATIONS

To select the proper irrigation system for a specific purpose, the system's initial cost must be considered as well as its operating costs. One type of system might have a lower initial cost but higher operating costs compared to another system. Comparisons should be made on cost-per-year bases over the entire life expectancies of the systems. This may be difficult to do because of the uncertainties associated with interest rates and fuel costs. These should be projected as nearly as possible over the life expectancy of the system.

Some advantages and disadvantages of various system types can be compared:

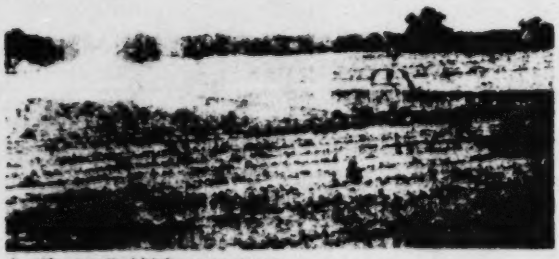
- High pressure guns are large energy users. The investment in this type of system is approximately $350-$400 per acre based on irrigation of 80-90 acres per week. Guns are very versatile systems. They are readily adaptable to odd shaped fields and acreages, and are easily transported.
- Permanent sprinkler systems are medium range energy users but require very large initial investments ($1000-$1200/acre). An advantage of permanent systems is that they can be designed to provide frost protection and crop cooling for certain crops. Also, labor costs are low.

A permanent irrigation system.

- Gravity flow systems (seepage) using furrows and ditches are relatively low energy users and have a low initial cost ($50-$150/acre) but are limited to use in soils with either high water tables or restrictive soil layers immediately (24 to 48 inches) below the crop root zone. A major disadvantage of these systems is that very large quantities of water must be pumped to maintain a water table at the proper height in addition to supplying the crop water requirements.

Seepage System Used in Pasture Production

- Drip or trickle irrigation systems are also low energy users. Investment cost is highly variable because it depends upon the row spacing of the crop. It is normally only considered to be economically feasible for widely spaced crops such as orchard crops ($300-$500/acre) or for high value crops where the higher initial investment cost might be justified to protect other large investments in the production system.



A self-propelled high pressure gun.

Because water is applied through perforated PE pipe or emitters near the soil surface, a greater percentage of the water can be stored in the plant root zone. Drip and trickle systems have the potential to save water and energy but may require increased management inputs due to system clogging and the necessity of filtering and chlorinating the water pumped.

A drip irrigation system.

BENEFIT-COST RATIO

Before installing any type of irrigation system, the producer should determine that it is an economically sound investment. Many times large expensive systems are purchased, but used only once or twice a year. This is false economy. Yields might not be increased sufficiently to warrant irrigation. For example, a farmer might increase his per acre yield $30 a year by irrigating, while irrigation costs $50 per acre. A good formula to remember is:

$$\frac{\text{Benefit Per Year (increase in yield)}}{\text{Cost Per Year (installation and operating)}} \quad \text{Must be} \geq 1,$$

otherwise it is uneconomical to irrigate. To better understand how irrigation could affect crop yields in specific locations, the agricultural producer should consult current research results. County Extension agents can provide this information.

INCREASE EFFICIENCY AND SAVE

Whether choosing a new irrigation system or operating an existing one, there are a number of practices that can be followed to increase irrigation efficiency and save water and energy. Good maintenance is always wise to protect an investment in machinery. Periodic engine tune-ups and pump adjustments are necessary to optimize efficiency. Tests by the University of Nebraska show that 20 percent of the irrigation power units in operation less than four years met only 50 to 74 percent of the standards of operating efficiency. This was due to lack of proper maintenance.

It is also extremely important to do business with a reputable, local dealer. Even though a grower could possibly purchase a less expensive system from a dealer in another area, repairs and service work must be available locally. The dealer can help the grower match the pump, well and power unit with the correct energy source for optimum efficiency.

Timing of water applications is important when considering irrigation practices that conserve water and energy. Irrigation is most critical during the flowering and/or fruit production stage of growth. For vegetable and citrus crops in central Florida, the fruiting seasons (early spring, late fall) are the periods of least rainfall.

Time of day is important also. The best time to irrigate is at night. This is true for several reasons. Water application efficiency is dependent upon wind velocity, temperature and humidity. When there is little or no wind, when the temperature is low, and when the humidity is high, water application efficiency is highest. Characteristically, these conditions prevail at night. Nighttime water application efficiency, or the ratio of the amount of water stored in the plant root zone as compared to that applied can be as high as 95 to 100 percent, while daytime efficiency can be as low as 50 to 60 percent.

It is important to apply the proper amount of water per application. Too much water might be harmful to the crop as well as wasteful and expensive. Too little water may be ineffective because of evaporation losses during application and interception losses from the crop canopy.

Irrigation scheduling or frequency of water application is closely related to amount of water applied per irrigation. Water should be applied only when a significant amount (normally 50 percent) of the available water in the plant root zone has been depleted. This can be determined from a knowledge of the soil water-holding capacity and the daily water use by the plant, or, more effectively, from a measure of the soil moisture status. Tensiometers are useful instruments for indicating soil moisture levels and for scheduling irrigations.

The grower should always seek new information to improve his production efficiencies. Any practices which results in improved crop production per unit of applied irrigation water contributes to the energy efficiency of the crop. Any practice which reduces the amounts of fuel and water used reduces the energy necessary for irrigation and contributes to the conservation of energy which so vitally affects our current and future production systems.

Institute of Food and Agricultural Sciences
Water Resources Council

WRC-8

IRRIGATION SYSTEMS FOR CROP PRODUCTION IN FLORIDA

Dalton S. Harrison, P.E.

Irrigated acreage in Florida has increased from 413,500 acres in 1959 to over 2 million in 1976.

Limited moisture-holding capacity of some Florida soils, increased scientific knowledge of crop requirements, uneven rainfall distribution, and demand for greater crop intensification make irrigation more appealing than ever before to farmers who have a high investment in crop production.

This is due to a general upgrading of the whole agribusiness operation rather than an expansion of total planted acreage. Irrigation is an economical management practice under the high average annual rainfall conditions in Florida because of poor seasonal distribution of rainfall and the relatively low water-holding characteristics of sandy soils. Besides preventing crop-water stress, irrigation may be used to protect the crop against heat and cold and to apply fertilizers and pesticides.

Irrigation systems currently used in Florida can be broadly classified as sprinkler, sub-surface, and trickle-drip.

An irrigation system is a production tool that must be carefully planned and managed. A system requires large capital expenditures with initial investments depending on many physical and use factors.

Sprinkler Systems

The need for mechanization to reduce labor costs and conserve energy and water has caused the irrigation industry to make many changes in equipment during the past 10 years.

Modern sprinkler irrigation systems can be grouped into three broad categories: (1) permanent, (2) solid-set, and (3) mechanical-move (center pivot and self-propelled or traveling gun) systems. Each has advantages and disadvantages to be considered when the farmer selects a system for a specific application. Other methods are seepage, crown or flood, and drip or trickle. Seepage costs vary due to the acreage installed. The higher the acreage the less the cost.

Permanent Systems

Permanent systems are generally used for high value cash crops such as citrus, orchard, and ornamentals, and for lawns and golf courses. Initial installation costs vary from $800 to $1200 per acre. Where frost or freeze protection is needed, some of these systems that have application rates of 0.15 to 0.35 inch per hour on a continuous basis for the entire acreage and serve a dual purpose that helps to justify the large investment costs.

Permanent systems now irrigate about 160,000 acres of citrus in Florida. Most of these systems used in citrus have low application rates of 0.10 to 0.15 inch per hour (Tables 1 and 2). Approximately 2,000 acres of ornamental ferns have permanent irrigation that provides both cold protection and irrigation. For fern nursery or subtropical fruit production, application rates vary from 0.25 to 0.35 inch per hour, and installation costs may be as high as $2500 per acre. Researchers in the U.S. have reported success in protecting strawberries, citrus nurseries, lettuce, alfalfa, and ornamental ferns against temperatures as low as 15 F. through the use of permanent and solid-set systems. Workers have reduced heat stress in strawberries and other crops by reducing soil surface, and leaf and fruit temperatures through intermittent sprinkling with either permanent or solid-set systems.

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The chief advantage of this type of system seems to be the low labor requirement of about .04 man-hours per acre-inch of water applied.

Solid-set Systems

A solid-set irrigation system is a layout of portable aluminum main and lateral pipelines to irrigate the entire field in one or more sections at one set to eliminate labor in moving laterals. Pipelines are placed in the field before the start of the season and left in place throughout the entire growing season. Costs vary from $800 to $1500 per acre.

The aluminum pipe system is usually designed for pipe and sprinkler coverage of the entire area, but only a portion of the system is operated at one time (one-fourth to one-fifth). Labor is required only to open and close the valves controlling flow to the various sections of the system.

Mechanical-move Systems

The systems used in Florida are divided into two general groups: (1) center-pivot and (2) self-propelled or traveling gun systems.

Center-pivot systems are the most mechanized in the mechanical-move group. They have gained major acceptance in many parts of the U.S., and the number of companies manufacturing these systems has grown from three to more than a dozen.

The center-pivot system is a radial move pipeline that rotates around a center pivot point. The system can be driven by water, oil hydraulic, gear, air, or electric motors. The lateral line is normally 6- or 7-inch steel or galvanized steel pipe. Towers on wheels support the pipeline at about 90 to 130 foot intervals and provide crop clearances from 8 to 13 feet. The systems were originally designed

Table 1. Characteristics of irrigation system used for orchard production in Florida, March 1977.

Type System	Acres Covered	Initial Investment* ($/Acre)	Variable Costs ($/Ac-In)	Irrig. Freq. (Days)	Estimate Life of System (Yrs.)
Permanent**	40-80	$800-1200	$1.30-1.75	8	25
Self-prop. Gun**	80-90	$300-375	$2.25-2.75	6	15
Seepage	Var.	$ 50-95	$1.00-1.25	Cont.	25
Crown or Flood	Var.	$125-170	$1.25-1.50	10-15	25
Drip***	Var.	$275-500	$0.25-$.50	Cont.	—

*For complete system, include distribution system, pump, pipe traveler, and power unit, where applicable.
**Figures from EC. Memo Report EC-69-8, modified by present 1976 prices.
***No attempt is made to estimate the life or labor requirements of drip systems since they have not been in use long enough to allow even an educated estimate to be made.

Table 2. Estimated labor requirements and total costs of irrigation systems for orchard crop production in Florida, March 1977.

Type System	Acres Covered	Labor Req. (Man/Hrs./Ac.-In.)	Hours Operation Per Day	Total Costs (Fixed & Var.) Per/Acre*
Permanent**	40-80	0.04	18	$85
Self-prop. Gun**		0.20	15	$75
Seepage	Var.	0.08	24	$15
Crown or Flood	Var.	.08	24	$24
Drip***	Var.	—	Variable	$25-40

*Applying an average of 12 inches per year for sprinkler, and 20-24 inches for seepage and flood systems for citrus based upon 1974 prices.
**Figures from EC. Memo Report EC-69-8, modified by present 1976 prices.
***No attempt is made to estimate the life or labor requirements of drip systems since they have not been in use long enough to allow even an educated estimate to be made.

to traverse slopes up to 5 percent; most units now handle slopes up to 20 percent.

The system's rotation speed varies depending on the amount of water desired per rotation—from .5 to 3 inches per application. Time between successive water applications can vary from 1 to 5 days.

The center-pivot system covers a circular area; it is also adaptable to square blocks of 12 to 350 acres with about 86 percent of the area receiving irrigation. Newer models have an automatic on-off end gun or a corner attachment that irrigates the four corners, or almost all the acreage. *The smallest size unit considered practical and economical under Florida conditions is the 160 acre system.* In smaller sizes the costs per acre is very expensive. Average initial costs (well, pump, motor, and system) for a 160 acre unit are about $39,000 or $300 per acre (Table 3). Labor costs are very low—about 0.05 man-hours per acre-inch of water applied (Table 4). The net acreage irrigated with a 160 acre system is approximately 138 when the automatic end gun is not used. Use of electric units and extras may lead to a fixed cost of $300 or more per acre.

Self-propelled or traveling gun units are simply large sprinklers that irrigate square or rectangular tracts. In 1966 the first self-propelled gun irrigation unit was introduced into the U.S. Today there are over 12 U.S. manufacturers. From 800 to 1500 units have been sold in Florida during the last 10 years. In Dade County some are truck mounted to serve as portable systems using shallow wells.

The "traveler," as it is called, is a giant sprinkler (125-1200 gpm gun) mounted on a 4-wheel transport and powered by either a water turbine,

Table 3. Characteristics of sprinkler and seepage irrigation systems for vegetable or field crop production in Florida, March 1977.

Type System	Acres Covered	Initial Investment* ($/Acre)	Variable Costs** ($ Acre-In)	Irrigation Frequency (Days)	Estimated Life of Systems*** (Years)
Center-pivot Self-propelled Gun	138	$300	$1.85	5.0	15
Portable Pipe, Or Gun (Manual Move)	80	$240	$3.25	5.0	10-15
Seepage	40-350	$55-$80	$0.75	Cont.	10-15

*For complete system, including distribution system, pump, well, and power unit.
**Variable costs include fuel or energy, labor, repair, and maintenance.
***Life of pump and well estimated 25 years.

Table 4. Estimated labor requirements and total costs of four types of irrigation systems for vegetable or field crop production, March 1977.

Type System	Acres Covered	Labor Required (Man-hrs./Acre-In.)	Hours Operations Per Day	Total Cost* (Fixed & Variable) $/Acre
Center-pivot Self-propelled Gun	138	0.05	24	$50-$60
Portable Pipe, Or Gun (Manual Move)	80	0.20	15	$50-$60
Seepage	40-350	1.00	10	$50-$75
		0.08	24	$15-$20

*For 6 inches irrigation annually except seepage which is approximately 18-20 inches annually. Includes interest and depreciation and variable (operating) costs.

Table 5. POWER AND FUEL COST COMPARISON

A - ELECTRICITY - Cost per hour of pumping
(Based on Motor Efficiency of 88% 1.18 hp - hr./KWH)*

Pump Load HP	Rates per kilowatt-hour 4¢	4½¢	5¢	6¢	8¢
10	$ .34	$ .36	$ .42	$ .50	$ .68
20	.68	.77	.84	1.02	1.36
30	1.02	1.13	1.28	1.52	2.04
40	1.36	1.53	1.70	2.04	2.72
50	1.70	1.89	2.12	2.54	3.40
75	2.54	2.88	3.18	3.82	5.08
100	3.39	3.83	4.24	5.04	6.78

B - GASOLINE - Cost per hour of pumping
(Based on 11.54 hp.-hr./gal. - Corrected for 5% drive loss)*

Pump Load HP	Fuel cost per gallon 40¢	45¢	50¢	60¢	70¢	80¢
10	$ .34	$ .38	$ .43	$ .51	$ .58	$ .69
20	.70	.79	.88	1.05	1.22	1.40
30	1.04	1.07	1.30	1.56	1.80	2.08
40	1.38	1.55	1.73	2.07	2.44	2.76
50	1.74	1.96	2.18	2.61	3.04	3.48
75	2.58	2.88	3.22	3.87	4.56	5.16
100	3.46	3.87	4.32	5.19	5.84	6.92

*Nebraska Standards for Engine Performance considered attainable in practice. Of 376 pumping plants tested in Nebraska 1956-62, only 33 or 8.8% exceeded the standard, 59% met or exceeded 75% of the standard. Efficiency of internal combustion engines can be expected to drop in normal use. Electric motor efficiency should change very little. Note: All costs per hour are rounded to the nearest cent. Costs are for fuel or power only, no lubrication, repairs, etc.

or oil hydraulic motor. The standard unit is the 550 gpm unit that handles 90-100 acres very well. The unit pulls a rubber hose (4⅛ to 4½ inch diameter, 660 feet long) and travels up to 1320 feet unattended. Some units may require longer hose lengths. Speed of the "traveler" can vary from 0 to 60 inches per minute. The traveler, gun, hose, and hose take-up reel retail for about $10,500 When the pump, well, power unit, and aluminum pipe are added, the total initial cost for an economic unit to handle 90 acres in 5 days is about $27,000 or $300 per acre (Tables 3 and 4).

One advantage of this system is the low initial cost per acre. Another advantage of the "traveler" system is its adaptability to fields of odd shape and size and to a wide range of plant and soil conditions.

A disadvantage is the friction loss in 660 feet of hose (25+ psi); the loss must be added to total dynamic head and is reflected in higher power requirements. Another disadvantage is the medium labor requirement of 0.20 man-hours per acre-inch (Table 4).

Additional Use of Sprinkler Irrigation Systems

In addition to crop cooling and cold protection, sprinkler irrigation systems are used for fertilizer distribution, municipal waste disposal, and in certain cases, pesticide application.

All other factors being equal, the cost of fertilizer application can be reduced by injecting liquid materials into the irrigation water for distribution. Many ornamental and citrus nurseries in Florida use irrigation systems for fertilizer distribution and pesticide application.

Researchers at the University of Florida found

Table 5. POWER AND FUEL COST COMPARISON

C - PROPANE - Cost per hour of pumping
(Based on 9.2 hp. - hr./gal. - Corrected for 5% drive loss)*

Pump Load	Fuel cost per gallon					
HP	35¢	40¢	45¢	50¢	60¢	70¢
10	$ .38	$ .44	$ .46	$ .55	$ .64	$ .76
20	.76	.88	.99	1.10	1.32	1.52
30	1.14	1.32	1.47	1.65	1.96	2.28
40	1.52	1.76	1.95	2.22	2.60	3.04
50	1.90	2.16	2.46	2.70	3.28	3.80
75	2.86	3.28	3.66	4.02	4.88	5.72
100	3.82	4.36	4.89	5.45	6.52	7.64

D - DIESEL - Cost per hour of pumping
(Based on 14.58 hp. - hr./gal/ - Corrected for 5% drive loss)*

Pump Load	Fuel cost per gallon					
HP	35¢	40¢	45¢	50¢	60¢	70¢
10	$ .23	$ .28	$ .31	$ .35	$ .42	$ .46
20	.47	.56	.63	.70	.84	.94
30	.70	.84	.95	1.05	1.26	1.40
40	.96	1.08	1.22	1.35	1.62	1.92
50	1.20	1.36	1.53	1.70	2.04	2.40
75	1.78	2.04	2.40	2.55	3.06	3.56
100	2.39	2.76	3.11	3.45	4.14	4.78

*Nebraska Standards for Engine Performance considered attainable in practice. Of 376 pumping plants tested in Nebraska 1956-62, only 33 or 8.8% exceeded the standard. 59% met or exceeded 75% of the standard. Efficiency of internal combustion engines can be expected to drop in normal use. Electric motor efficiency should change very little. **Note:** All costs per hour are rounded to the nearest cent. Costs are for fuel or power only. Lubrication, repairs, etc., are estimated at $20, $13, $12, and $2, respectively, for each 100 hours for Diesel, Gasoline, Propane, and Electric.

that all the nitrogen and potassium for tobacco production can be supplied in liquid form through the irrigation system, resulting in quality and yield as good as that achieved through dry application with conventional systems.

Sub-surface Systems

Seepage irrigation of pastures, vegetables, sugarcane, and citrus is one of the lowest cost systems available in Florida. The system distributes water through the soil to irrigate the crop by the high (18-20 inches) hydraulic conductivity of the soil, keeping a head so water will move horizontally. Additional information on seepage irrigation is given in Florida Extension Circular 309.

Other types of surface systems generally used for Florida citrus are referred to as "crown" or "flood" irrigation systems. Estimates of costs and labor characteristics of these types are presented in Tables 1 and 2.

The water utilization efficiency of seepage systems is low, aproximately 50 to 60 percent, but initial investment and operating costs are low (Tables 1-4).

Florida now has about one million acres under sub-surface or seepage type irrigation systems. Most of this acreage is divided among the following crops: citrus, pasture, sugarcane, vegetables, and 5,000 acres of minor crops.

Drip or Trickle Irrigation Systems

During the last 4 years, approximately 14,000-16,000 acres in Florida have been placed under drip irrigation: 12,000 acres of citrus and other orchard crops and 4,000 acres of vegetable and other crops.

Drip irrigation is the application of water to crops through a low pressure (4-15 psi)distribution system. The system consists of plastic tubing installed on or below ground surface as either twin-wall or porous tubing, in addition to strategically spaced emitters presently in use on orchard crops. Initial costs are $275-$500 per acre; however, lower energy use and water savings make drip systems attractive.

With use of drip irrigation, researchers have reported significant increases in crop yield and water savings for grapes, orchard crops, and vegetable crops. Preliminary reports indicate that drip irrigation has the following potential advantages: (1) increased yields, (2) accelerated growth, (3) adequate moisture in root zone all the time, (4) crops not subjected to cycles of extreme soil moisture varying from saturation to wilting point, (5) conservation of water, (6) area between rows remains dry, which reduces weed growth, (7) no run-off on hillsides or rolling ground, (8) improved crop quality, and (9) use of poorer quality water with less damage to crops, except in cases of iron and sulfur.

Because drip irrigation is relatively new in Florida, there are problems and unanswered questions that should be pointed out. Each situation in which drip irrigation might be used should be evaluated by a qualified person. Perhaps the greatest problem experienced under Florida conditions is clogging of emitters. Iron and sulfur in the irrigation water react with certain bacteria and cause production of an ochre sludge or slime that stops water flow under low pressure. Also to be considered are: (1) degree of water filtration required, (2) basic information on the exact wetting zone for different soil types under various discharge rates, (3) numbers of emitters required per tree or row, and (4) potential for applying fertilizers through the system. The need is great for more knowledge and experience on which to base design and operating procedures. Current experiments around the state on most crops will increase our knowledge of drip or trickle irrigation.

Energy Costs in Irrigation

Energy costs are a major factor in determining which power source to use. Table 5 shows energy cost computation for different energy sources. The purchaser should make a thorough investigation of future availability of fuel or energy, cost estimates, and supply potential before deciding which energy source to use.

Summary

Many types of sprinkler and sub-surface irrigation systems are available. Some are adapted to large square and rectangular fields and flat or gently rolling terrain. Others are limited to soils with low infiltration rates, and some to low growing crops. Most mechanical-move systems have been developed for large acreages. No one system is applicable to all situations.

Growers must invest much capital when buying an irrigation system. The benefit to cost ratio should be determined clearly before a decision is made. Growers contemplating small acreage irrigation should not consider cost estimates in Tables 1-4. These estimates are not applicable for systems with less acreage than stated in the tables. This is especially true for center-pivot and traveling or self-propelled gun systems.

LOW ENERGY TECHNOLOGY
ENERGY CONSERVATION IN FIELD CROP PRODUCTION

UNIT: FIELD CROPS

MODULE: PEST CONTROL

STUDENT PERFORMANCE OBJECTIVES	CONTENT	TEACHING-LEARNING ACTIVITIES
The student will be able to:		
1. Name five kinds of pests and give an example of each.	A pest is any organism that is harmful to humans, animals or crops. Pests can be Insects Weeds Diseases Mites Nematodes Mice Other	Read handout, Pests
2. Write in 50 words or less, a definition of Integrated Pest Management.	Integrated Pest Management is a system that makes use of a combination of various pest control methods to keep pests from doing serious damage. This system can save both money and energy and reduce harmful effects on the environment.	Read handout, Integrated Pest Management: The Concept and Principal Show slide/cassete set, "IPM" available from IFAS editorial
3. List the six steps involved in a successful, low energy IPM program.	IPM Program Identification of pest and beneficial organ-Isms Preventative cultural practices Monitor pest populations (scouting) Prediction of loss and risk Decision or action to be taken Evaluation and follow up	Discuss: transparency Steps for Energy Savings in Pest Management Read handout Survey Sheet. Each student will interview parents or local farmer to get information on pest control methods being used and complete survey sheet. Results will be compiled and reported to the class for discussion.

LOW ENERGY TECHNOLOGY
ENERGY CONSERVATION IN FIELD CROP PRODUCTION

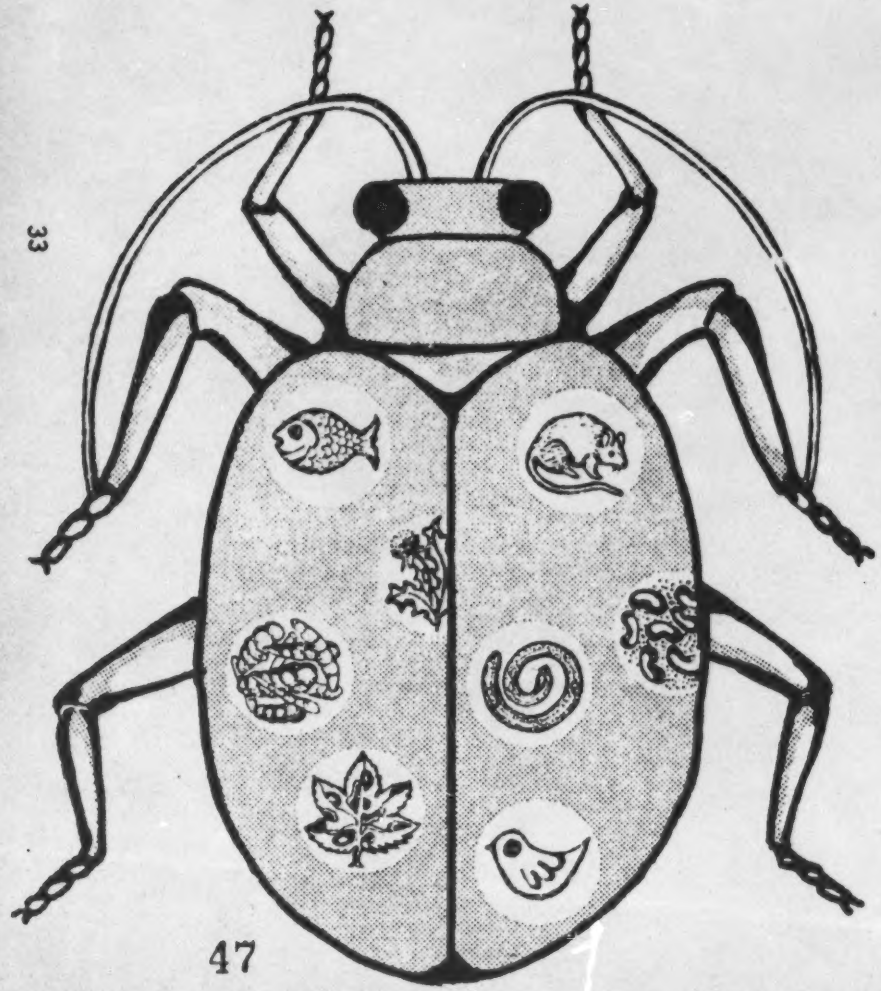
UNIT: FIELD CROPS

MODULE: PEST CONTROL

STUDENT PERFORMANCE OBJECTIVES	CONTENT	TEACHING-LEARNING ACTIVITIES
The student will be able to:		
4. List three cultural practices that reduce energy in controlling weeds.	Weed control programs Crop rotation Crop competition Mulches Application of herbicides in irrigation system	Read handout, Weed Control in Field Crops Have students go through a field and identify the weeds growing there. Have them suggest three ways that the weeds could have been prevented. Have students complete Evaluation.

PESTS

Cooperative Extension Service
Center for Environmental Programs
Institute of Food and Agricultural Sciences
University of Florida, Gainesville

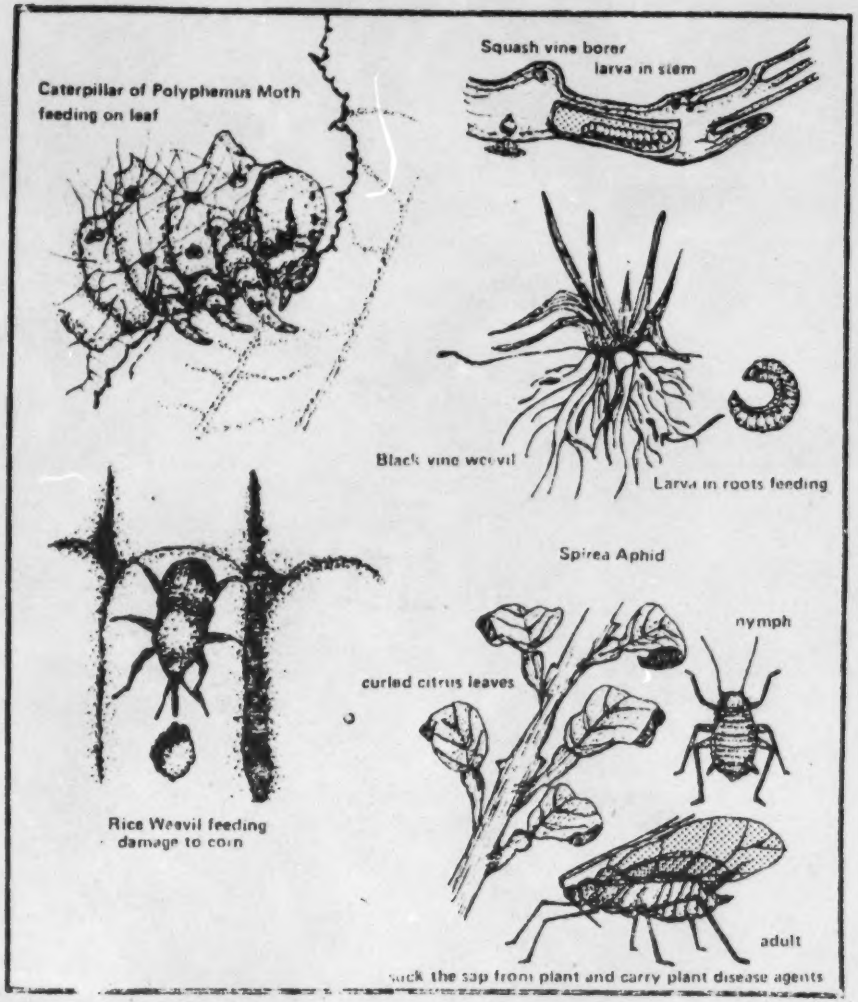


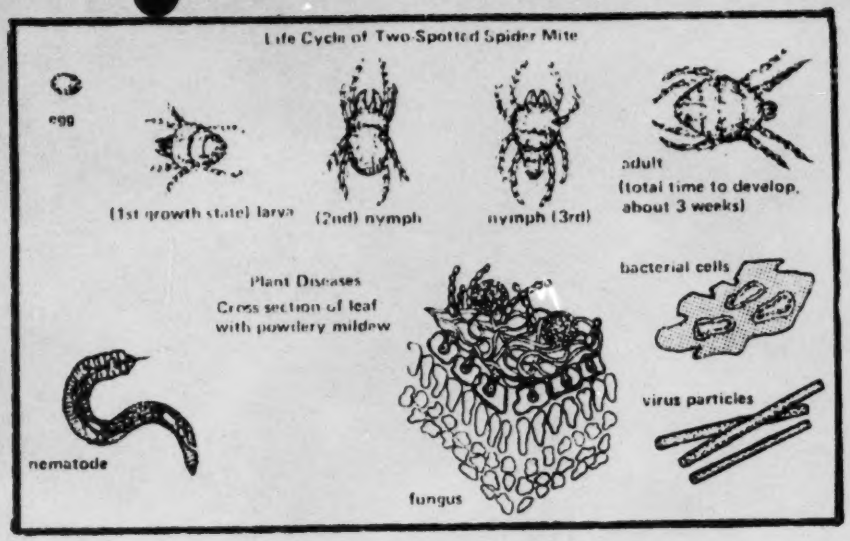
INSECTS

Many types of insects affect crops. They cause damage in a variety of ways. They may:

* feed on leaves,
* tunnel or bore in stems, stalks, and branches,
* feed on and tunnel in roots,
* feed on and in seeds and nuts,
* suck the sap from leaves, stems, roots, fruits, and flowers, and
* carry plant disease agents.

The plants are damaged, weakened, or killed. This causes reduced yields, lowered quality, and ugly plants or plant products that cannot be sold. Even after harvest, insects continue their damage in the stored or processed products. Insects also feed on and in man and other animals.





MITES, TICKS, AND SPIDERS

Mites, ticks, and spiders are closely related to insects. The main differences are that the adults have eight jointed legs instead of six and have two body regions. They do not have wings.

PLANT PARASITIC NEMATODES

Nematodes are small, unsegmented roundworms. Different kinds live in the oceans, in fresh water, as parasites of animals and man, in the soil, and as parasites of plants. The plant parasitic nematodes comprise a very small fraction of all the kinds of nematodes known to exist. However, every kind of plant has some kinds of nematodes which can live on it and may damage it in some way. The mild climate, the sandy soils, and the great variety of plants grown combine to give Florida more kinds and more severe problems with plant nematodes than almost anywhere else.

How Does Nematode Feeding Affect Plants?

- Nematodes cause lesions, discoloration, deformity, and in some cases, complete devastation in the penetration and feeding areas.
- Plants under attack by nematodes lose vigor and become unthrifty.
- The size and quality of fruits and vegetables are reduced.
- Nematodes cause decline, and in extreme cases, death of the plant.
- The puncture wound left by the stylet opens the door for fungal or bacterial invasion, which may do more damage than the nematode.

PLANT DISEASES

What is a plant disease? A plant is diseased when its chemistry, structure or reproductive ability is abnormal.

What causes plant diseases? Plant diseases can be caused by either non-living or living agents. The most common living agents causing plant diseases are:

- fungi,
- bacteria,
- viruses.

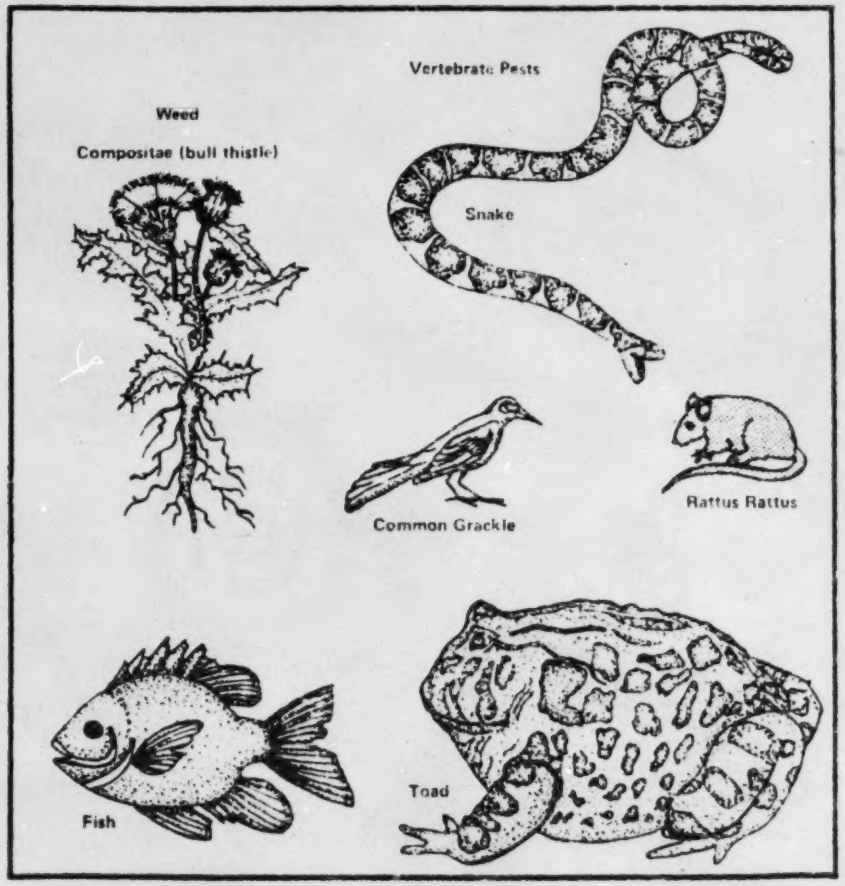
WEEDS

A weed is simply "a plant out of place." Weeds are a problem because:

- they reduce crop yields,
- they [illegible] land use efficiency,
- they reduce product quality,
- some cause skin irritation in man, and others are poisonous to man and animals, and
- they spoil the beauty of turf and landscape plants.

RECOGNIZING COMMON FEATURES OF VERTEBRATES

All vertebrate animals have a jointed backbone. They include fish, snakes, turtles, alligators, lizards, frogs, toads, salamanders, birds, and mammals.



SUNSHINE STATE PESTICIDE PROGRAM

This public document was promulgated at an annual cost of $459.15, or 2.3¢ per copy to inform Florida producers of proper pesticide use.

11-20M-75

· HANDOUT

INTEGRATED PEST MANAGEMENT: THE CONCEPT AND PRINCIPLE

Integrated Pest Management (IPM) is a relatively new approach to an old problem: How to insure crop protection and maintain yield and quality through controlling pest populations while minimizing effects on people and the environment. IPM attempts to make the most efficient use of the strategies available to control pest populations by taking action to prevent problems, suppress damage levels and use chemical pesticides only where needed. Rather than seeking to eradicate all pests entirely, IPM strives to prevent their development or to suppress their population numbers below levels which would be economically damaging.

Integrated means that a broad, interdisciplinary approach is taken using scientific principles of crop protection in order to fuse into a single system, a variety of methods and tactics.

Pests include insects, mites, nematodes, plant pathogens, weeds, and vertebrates which adversely affect crop quality and yield.

Management refers to the attempt to control pest populations in a planned, systematic way by keeping their numbers or damage within acceptable levels.

The goals of an IPM program are:

(1) Improved Control. IPM will provide more effective pest control to maintain and sometimes improve quality and yield. For example, by implementing alternatives to strict dependence on pesticides, IPM makes use of a balanced approach, relying for example, on cultural practices, natural enemies (parasites or pathogens) and host plant resistance as well as chemicals. By reducing the use of pesticides, IPM will be able to emphasize biological control and the conservation of natural enemies already occurring in the field. IPM may provide new weapons for the producer's arsenal against pests.

(2) Pesticide Management. IPM will supply a more efficient and sensible approach to pesticides, thus increasing their effectiveness and useful life span and decreasing possible adverse effects.

(3) Economical Crop Protection. IPM will control pest populations more economically. For example, simply by treating crops as needed, instead of merely by the calendar, IPM can often reduce protection costs by reducing the amount of pesticide used and the number of applications.

(4) Reduction of Potential Hazards. IPM will better safeguard peoples health and the environment from possible harmful side effects associated with pesticides.

These are the steps towards a successful, low energy pest management plan.

(1) The identification of key pests and beneficial organisms is a necessary first step. In addition, biological, physical and environmental factors which affect these organisms must be considered.

(2) Preventative cultural practices are selected to minimize pest population development. These practices include soil preparation procedures, use of resistant plants, specified planting dates, etc.

(3) Pest populations must be monitored by training "scouts" who routinely sample fields and fill out a scouting report with information on pest population densities.

(4) A prediction of loss and risks involved is made by setting an economic threshold. Pests are controlled only when the pest population threatens acceptable levels of quality and yield: Remedial action is taken. The level at which the pest population or its damage endangers quality and yield is often called the economic threshold. The economic threshold is set by predicting potential loss and risks at a given population density. This estimation takes into account weather data, state of crop development, markets, risk benefit, costs and kinds of control available.

(5) An action decision must be made. In some cases, pesticide application will be necessary to reduce the crop threat, while in other cases, a decision will be made to wait and rely on closer monitoring.

(6) Evaluation and follow-up must occur throughout all stages in order to make corrections, assess levels of success and to project future possibilities for improvement.

WHO BENEFITS FROM IPM?

- Producers benefit from decreased production costs and by having a more balanced and effective means to control pests, and by reduced risks to crop yield and people's health.

- Farm workers benefit by reduced exposure to pesticides and avoid risks upon re-entry to work areas.

- Chemical companies benefit by having a longer, useful life for their pesticides, insofar as they may avoid a build-up of resistance to their chemicals.

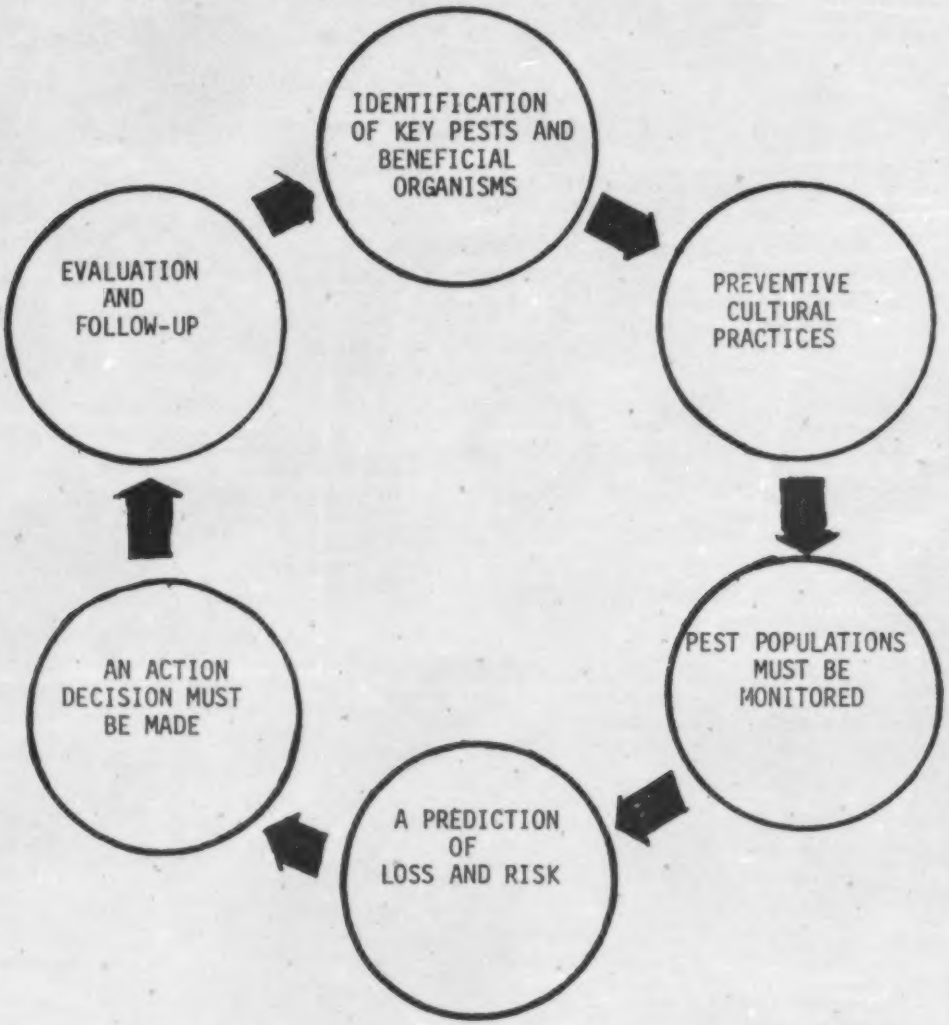
- Consumers' health benefits by enjoying food with minimal or no pesticide residue.

- Fish and wildlife benefit by less exposure to pesticides in their food chain.

- The water, the air and the soil system will remain less contaminated from misuse of pesticides.

- Society as a whole will ultimately reap benefits from maintained levels of production, energy savings, better quality food and an environment less contaminated by potentially dangerous chemicals.

STEPS FOR ENERGY SAVINGS
IN PEST MANAGEMENT


IDENTIFICATION OF KEY PESTS AND BENEFICIAL ORGANISMS
PREVENTIVE CULTURAL PRACTICES
PEST POPULATIONS MUST BE MONITORED
A PREDICTION OF LOSS AND RISK
AN ACTION DECISION MUST BE MADE
EVALUATION AND FOLLOW-UP

HANDOUT

SURVEY SHEET
PEST CONTROL METHODS ON THE FARM

Crops grown

1)

2)

3)

Cultural practices used for pest control

1)

2)

3)

Resistant crop varieties

1)

2)

3)

Do you hire scouts?

How often are fields scouted?

Chemical pesticides used

1)

2)

3)

4)

Pests treated with pesticides

Insects

1)

2)

3)

Weeds

1)

2)

3)

Diseases

1)

2)

3)

Nematodes

Approximately how much is spent on pesticides each year?

Do you use any biological control methods?

1)

2)

Livestock pests - do you use

dustbags?

eartag?

spray?

HANDOUT

WEED CONTROL

Successful weed control is essential for economical crop production. Improved yields as a result of successful weed control may improve yields per gallon of fuel consumed in crop production. Reduced quality or harvesting problems caused by weeds may require weed control measures regardless of energy costs. Producers of certified seed are severely restricted in the amount of weed seed that can be present in their crop. In such a situation, successful weed control may make the difference in having a salable crop. Fortunately, cultural and chemical methods are available to to improve energy efficiency of weed control.

Crop rotation, besides reducing other crop pests, can improve the efficiency of weed control. Certain broadleaf weeds may be difficult or impossible to control with herbicides, in broadleaf crops, e.g. Florida beggarweed in peanuts. Successful control of these weeds in preceeding grass crops can reduce weed populations in subsequent crops.

Crop competition is one of the most important, but often one of the most overlooked, tools in weed control. A good crop stand, which emerges rapidly and uniformly and shades the middles early, is very helpful in reducing weed competition. Increased planting rates and narrow rows result in more rapid covering of middles and give the competitive advantage to the crop plants. Soil moisture at planting can be very important since many weed seeds will germinate at lower soil moisture than many crop seeds. When weeds germinate before the crop they will have the competition advantage. Utilizing good management practices necessary for high yields, such as choosing a well adapted variety, good fertility, maintaining proper soil ph, and using adequate plant populations can help give the crop the competition advantage.

Utilization of mulches in addition to other advantages can reduce dependence on chemical weed control. Mulches, whether they are black plastic, paper, .. dormant, or chemically killed sod control weeds by preventing light from reaching germinating seedlings and therefore preventing photosynthesis and growth.

Chemical weed control success requires proper application methods and proper timing of herbicide applications. Mistakes may require retreating, at increased costs for time and energy to do the job right the second time, or may require the use of other less effective or efficient methods.

Energy consumed in application of herbicides can be reduced by using different application methods. Herbicide application in irrigation water saves fuel used in conventional application and reduces soil compaction since another trip across the field by the tractor is eliminated. Some herbicides which can be applied in irrigation water are compatible with certain fluid fertilizer materials so that irrigation, fertilizer and herbicide application can be accomplished in one operation using little more energy than would be required for irrigation alone.

Soil applied preemergence herbicides in general, require more fuel for application than post-emergence foliar applied herbicides since most soil applied herbicides need to be incorporated into the soils.

New application tools such as the rope wick applicator allow selective application of non-selected foliar applied herbicides, provided a height difference exists between the crop and weeds.

The rope wick applicator basically consists of a boom-reservior made of plastic pipe, and braided nylon rope "wicks" inserted (at both ends of the rope) into holes drilled in the plastic pipe. Herbicides in the reservoir flows into the rope by capillary action. Mounted on a tractor so the boom is higher than the crop, the applicator is driven across the field. When leaves and stems of weeds are brushed by the wicks, herbicide is transferred from the wicks to the weeds. Herbicides can be applied with this system on windy days without the hazard of drift.

This application method uses a much lower volume of chemical per acre than conventional spray application. Therefore, the energy used to produce the amount of herbicide to treat each acre is reduced. Since the material is foliarly applied, no additional energy is needed to incorporate the herbicide into the soil. Finally since no pto powered pump is involved, applicators may be able to use the most efficient gear/engine speed combination with no need to consider pto speed.

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EVALUATION

1. Name five kinds of pests and give an example of each.

Pest	Example

2. Write in 50 words or less, a definition of Integrated Pest Management.

3. List the six steps involved in a successful, low energy IPM program.

Step 1.

Step 2.

Step 3.

Step 4.

Step 5.

Step 6.

4. List three cultural practices that reduce energy in controlling weeds.

1.

2.

3.

LOW ENERGY TECHNOLOGY
ENERGY CONSERVATION IN FIELD CROP PRODUCTION

UNIT: FIELD CROPS — MODULE: FERTILIZATION

STUDENT PERFORMANCE OBJECTIVES	CONTENT	TEACHING-LEARNING ACTIVITIES
The student will be able to:		
1. Collect soil samples for soil testing.	Certain information is required by law on commercially prepared fertilizers. This includes:	
2. Determine the correct fertilizer analysis for optimum crop growth after a soil test has been made.	Florida registration number Brand name Net Weight Address of manufacturer If organic material is indicated, must identify the specific organic nutrient. The guaranteed analysis section is divided into Primary plant nutrients . nitrogen . phosphoric acid . soluble potash Secondary plant nutrients Chlorine content	Have students take soil samples. Check with county agent on the correct procedure. Have samples tested and let students identify the analysis of fertilizer which would be most appropriate for modifying this soil sample. Make sure the student writes down the primary and secondary plant nutrients.

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LOW ENERGY TECHNOLOGY
ENERGY CONSERVATION IN FIELD CROP PRODUCTION

UNIT: FIELD CROPS — MODULE: FERTILIZATION

STUDENT PERFORMANCE OBJECTIVES	CONTENT	TEACHING-LEARNING ACTIVITIES
The student will be able to:		
3. Explain two ways of saving energy when applying fertilizer.	Energy can be reduced by improving the efficiency of fertilizer, applications soil testing use of lime use of legumes type of fertilizer used other crop management practices	Read Handout, Proper Fertilizer Management saves Energy. Divide students into groups. Select a vegetable crop for each and have them research information. to determine the best variety for the locale what soil it will grow best in what types of fertilizer should be used how to apply efficienty (using 2 methods) What is the proper Ph for growing? Discuss information in class. Have students complete Evaluation.

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Proper Fertilizer Management Saves Energy
EC-27

Stretch America's Vanishing Energy

FLORIDA COOPERATIVE EXTENSION SERVICE

Proper Fertilizer Management Saves Energy

J. B. Sartain, Fertilizer and Lime Technologist

ENERGY CONSERVATION FACT SHEET

University of Florida • Institute of Food and Agricultural Sciences

INTRODUCTION

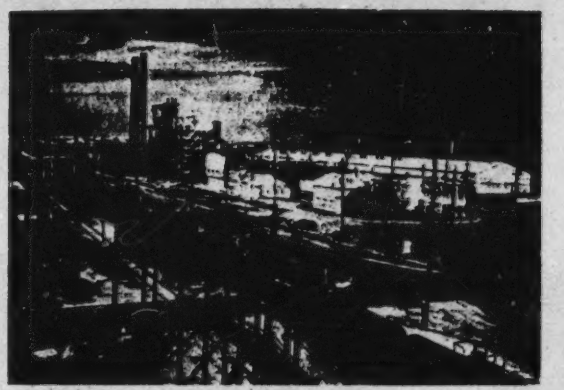
Agriculture and food systems use about 13 percent of the total U.S. energy consumption which (in 1970) represented 4,667 trillion Btu (British thermal units) of fossil fuel energy. The fertilizer industry, the heaviest energy consumer of agricultural manufacturing industries, used 504 trillion Btu, accounting for 12 percent of the Btu for agriculture and 1.55 percent of our total energy consumption.

FERTILIZER INDUSTRY

A total of 479 trillion Btu, 95 percent of the total used in fertilizer manufacturing, was consumed in the manufacture of nitrogen fertilizer materials in 1972-73 (Table 1). Natural gas is the primary fossil fuel used to produce anhydrous ammonia, a nitrogen fertilizer, accounting for 96 percent of the 40.9 million Btu needed to produce a ton of this product. Ammonia is the basic source of nitrogen for fertilizer purposes. Ammonia is used directly in crop production and in manufacturing urea, ammonium nitrate, sodium nitrate, calcium nitrate and ammonium sulfate. On the other hand, the manufacture of phosphate and potash materials consumed approximately 5 percent of the total energy used in manufacturing fertilizer materials.

Table 1. Energy Requirements to Produce Selected Fertilizer Materials in 1972-73

Materials	Btu per ton (thousands)	Tons of final product (millions)	Total Btu (trillion)
Nitrogen (N)	21.5	22.3	478.8
Phosphate (P_2O_5)	0.9	14.6	13.7
Potash (K_2O)	2.1	5.2	11.0
Total			503.5



Fertilizer plants such as this one depend largely on fossil fuels.

FUTURE IMPLICATIONS

Total energy requirements for selected fertilizer materials are projected to increase by 17 percent to 591 trillion Btu in 1980. With natural gas reserves decreasing, the fertilizer industry will be forced to seek other sources of feed stock (raw materials) and non feedstock energy.

Use of any known sources of hydrogen feedstock other than natural gas results in significant increases in production cost of nitrogen (Table 2). Naphtha

Table 2. Raw Materials Cost Portion for Ammonia Production

Raw material (feedstock)		Production Cost	
Amount required per ton Ammonia	Cost of feedstock per unit	Raw material cost/ton NH_3 $/ton	Production cost/ton NH_3 $/ton
Natural gas 38,500 MSCUFT*	1.50 MSCUFT	57.75	91.00
Naphta 0.88 ton	69.25/ton	60.94	98.00
Heavy oil 0.965 ton	63.50/ton	61.28	103.00
Coal 2.2 ton	42.00/ton	92.40	150.00

*MSCUFT = 1000 standard cubic feet

COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS, STATE OF FLORIDA, IFAS, UNIVERSITY OF FLORIDA, U. S. DEPARTMENT OF AGRICULTURE, AND BOARDS OF COUNTY COMMISSIONERS, COOPERATING

and heavy oil reserves are finite. With present technology, coal appears the most likely future feedstock. At the present cost of coal, this could result in a 65 percent increase in production cost of ammonia.

This increase will be passed on to the farmer in the form of higher fertilizer prices. Therefore, to conserve energy sources and maximize profit from a farming operation, we must seek ways of improving the efficiency of the fertilizer we use.

IMPROVING FERTILIZER EFFICIENCY

There are several ways we can improve the efficiency of the fertilizer.

Soil Testing

Optimum economic fertilization is a must and can best be accomplished by a well-planned soil testing program. By taking a representative soil sample of the area to be farmed and having it analyzed for primary plant food nutrients, you can plan your fertilizer and liming program and apply the recommended rate of only those plant nutrients which were shown to be deficient by the soil test.

In many cases, a properly followed soil testing program will result in more efficient use of the energy available fertilizers. County Extension offices can offer assistance in taking soil samples.

Following a soil testing program helps reduce fertilizer requirements.

Use of Lime

The proper use of lime can have a very significant effect on fertilizer utilization. Over liming can reduce nutrient availability and be as detrimental as under liming. Most of the essential plant nutrients increase in solubility and availability as the soil reaction is increased from pH 5.0 to 6.5 by liming. This increase in availability with liming promotes more efficient utilization of both native soil fertility and added fertilizer nutrients.

The solubility of phosphorus compounds in the soil is acutely affected by soil pH. Under acid conditions (low pH), phosphorus is precipitated as iron and aluminum phosphates which are relatively insoluble and unavailable. With liming, phosphorus compounds become more soluble and could potentially reduce the need for phosphorus fertilizer.

Micronutrients, such as manganese, may be present in large quantities and become toxic to plant growth under acidic conditions. Proper liming decreases the solubility of manganese compounds and, therefore, reduces the potential toxicity.

The capacity of a soil to absorb cationic nutrients is referred to as the cation exchange capacity. The exchange of our soils comes mostly from Kaolinitic clay and organic matter. Soil reaction (pH) has a significant effect on the exchange capacity of these two soil components. As the soil pH increases, the number of active exchange sites on these two materials increases. This increase in exchange capacity is important in the retention of fertilizer nutrients such as calcium, magnesium, ammonium, and potassium, against leaching losses.

The leaching loss of K (potassium) was reduced by 27 percent by liming a Norfolk fine sandy loam (Table 3) making more K available to the crop throughout the growing season and increasing the utilization efficiency of the potassium fertilizer.

Table 3. Effect of Liming on Leaching Loss of Potassium.

Soil	Percent of K held on exchange sites	
	Acid	Limed
Norfolk fine sandy loam (C.E.C.* 2-5 meq/100g)	22	49
Cecil clay loam (C.E.C. 10-12 meq/100g)	60	89

*C.E.C. = Cation Exchange Capacity

Use of Legumes

An outstanding characteristic of legumes is their ability to obtain N (nitrogen) from the air. Legumes, whose roots live in the soil with bacteria known as **Rhizobium**, are able to convert atmospheric N to a form which can be used by the plant. Therefore, cultivation of legumes has the double advantage of producing a valuable crop with the addition of little or no N fertilizer. While this fact has been known for decades, it is now more economically feasible to utilize legumes because of the rising cost of nitrogen fertilizers.

Most cultivated legumes will fix 150-400 pounds of nitrogen/acre/year.

Legumes vary in their ability to "fix" nitrogen. However, most cultivated legumes will "fix" 150-400 pounds of N/acre/year. The "fixed" nitrogen may be incorporated in the soil as a green manure for subsequent crops.

Research has shown that the amount of N contained in legume-grass forage was approximately equal to that in grass forage with 400 pounds of N/acre/year applied. At 20¢/pound of N, this would result in a savings of about $80/acre/year to a farmer and a considerable savings of energy used in the production of nitrogen fertilizer on a national basis.

Other Crop Management Practices

Selecting the best adapted variety for your cropping area can result in the maximum potential production of the crop and a higher return per pound of fertilizer consumed. Fertilizer placement and time of application can also increase effectiveness and utilization of applied fertilizer.

Type of Fertilizer Material Used

High analysis or concentrated fertilizer materials require more energy to produce on a per pound of nutrient basis than low analysis materials; however, the savings in energy used in transporting and applying these high analysis materials may make them more economical to use. Also the salt index of low analysis materials is lower, which reduces the salt burn potential.

The development and use of slow release materials which follow the nutrient requirement of the crop and avoid leaching losses can also aid in reducing the amount of fertilizer applied per unit of yield.

CONCLUSION

Your county Extension office can help with local recommendations on adapted varieties, rates of fertilizer applications and suitable fertilizer formulas.

With the impending energy shortage, especially in natural gas, we should make every effort to conserve the use of fertilizers. By using wise management practices, we can increase yield per pound of fertilizer with no decrease in profit. Furthermore, some of our fossil fuel energy resources will be conserved for a future generation.

This fact sheet was promulgated at a cost of $296.15, or 3 cents per copy to inform producers on how proper fertilizer management saves energy.

COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS
(Acts of May 8 and June 30, 1914)
Cooperative Extension Service, IFAS, University of Florida
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K. R. Tefertiller, Director

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EVALUATION

1. Identify the nutrients needed in the soil of the sample that was taken.

2. What fertilizer did you select and why?

3. Explain two ways of saving energy when applying fertilizer.